National Intelligence Council **Confidential**

Memorandum

Estimating Heroin Imports Into the United States

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NIC M 84-10002
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NIC M 84-10002

ESTIMATING HEROIN IMPORTS INTO THE UNITED STATES

Information available as of 16 March 1984 was used in the preparation of this Memorandum.

CONTENTS

SCOPE NOTE

This Memorandum reports the results of an effort to develop a system dynamics model of US heroin imports as an analytical aid [redacted] we expanded the model to use it to estimate heroin imports for 1983, [redacted]

The model presented in this Memorandum provides a way to *estimate* various aspects (such as, purity, price, number of heroin users, or amount of imports) of the heroin market in the United States for any *past* period when any one aspect (say, purity or imports) is known. It does not *forecast* future aspects of the market for *future* time periods.

We believe the model offers a way to understand any heroin market that resembles the market in the 10-year period (1973-82) used as the basis for the development of the model. Since heroin supplies fluctuated up and down by almost 50 percent during this period, we believe it can handle successfully any swings in supplies to the United States that are likely to occur in the next several years.

Data supplied by the Office of Intelligence of the Drug Enforcement Administration were essential to the development of this model. This Memorandum has been discussed with the Directorate of Intelligence and the Directorate of Operations and approved by the National Intelligence Council. Comments are welcome and should be addressed to its authors, [redacted] Model documentation and other technical details are available from [redacted] who designed and developed the simulation model.

KEY JUDGMENTS

Using a system dynamics model of US heroin imports over the last 10 years, we estimate that a little less than 5.5 metric tons of heroin was imported into the United States in 1983. The model enables us to derive an estimate of 1983 imports many months before import figures are available from any other source.

We developed this model by combining expert opinion with quantitative data relating to heroin supply and usage in the United States. We identified the critical factors influenced by how abundant heroin supplies are in the US market at any given time, and we examined how changes in one factor affect the others. After these basic relationships were established, heroin import figures for the period 1973-82 that are commonly accepted by the various agencies concerned with drug abuse were entered in the model. With only these data as direct input, the model then forecast the size of the user population, price, purity of heroin consumed, and number of heroin-related deaths for that same period. These figures were compared with independently available data on most of these heroin market aspects to establish the model's validity.

In view of the relative simplicity of the model and the sampling and statistical problems involved in measuring various dimensions of heroin supply effects, the correspondence between the model's numbers and the independently measured numbers was better than expected. In particular, the correspondence between purity measured in heroin samples collected by the Drug Enforcement Administration (DEA) and the purity estimated by the model over the 10-year period was remarkably close.

The relative precision with which the model predicted changes in heroin purity over an extended period indicates a relationship between purity and such other factors as imports and consumption that is sufficiently strong to suggest that purity figures alone can be used as a powerful, timely indicator of the abundance of heroin in the United States at any given moment. It may be possible, for example, to use purity figures to estimate whether and how much imports of heroin and the size of the US heroin addict population are expanding, holding steady, or declining.

The advantage of using purity as an indicator for these other factors is that purity measurements are usually available regularly on a

fairly "real time" basis, while import statistics often have to be deduced from fragmentary evidence and are months late, and addict population size figures frequently do not exist at all. The model, for example, enables us to use purity measurements to estimate imports before such information is available from other sources, as we did for 1983. [redacted] 25X1 we were able to compare purity data 25X1 produced by the model with existing sample purity data to correct or fill in missing import figures. In particular, the model enabled us to deduce otherwise nonexistent Turkish import figures for 1971-72, and spotlight probably erroneous Mexican import figures for 1975.

This modeling effort is still in a developmental phase. We need additional time and research to determine how robust it is, whether it can be extended to non-US markets, and whether it can be adapted to deal with illegal drugs other than heroin. In theory, however, several additional applications of the model may be possible:

— If, for example, we could construct a model of the heroin supply-and-demand situation in major producing regions outside the United States, we might be able to determine how much heroin is available for export to the United States several months before heroin from those sources actually began to arrive.

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— Third, if a regular relationship between such factors as prices and imports can be discovered for other illegal drugs such as cocaine, it might be possible to use the model to understand the market for other drugs.

— Finally, a more ambitious but theoretically feasible use would be to attempt to develop a comprehensive illegal drug model that could illuminate dimensions of multiple drug use and the trade-offs that might occur in concentrating intelligence and law enforcement resources against particular drugs in the national system.

DISCUSSION

1. One problem that plagues strategic narcotics analysis—analysis of major trends in the illegal production, trafficking, and consumption of assorted dangerous drugs—is the poor quality or lack of data on crucial aspects of what is grown, manufactured, moved, and consumed in the international illegal drug world. There is no fully adequate substitute for data, but there are useful analytical aids that help get around the problem by making better use of the data that are available.

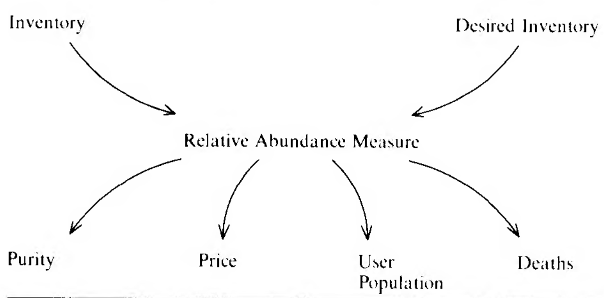
2. [redacted] The method used in designing the model, system dynamics, has several features that are highly advantageous in this sort of analysis—including, for example, the use of expert opinion to identify the critical factors that influence the behavior of the system and to see how a change in one factor affects the others.

3. This paper illustrates how the fundamental factors affecting the behavior of the heroin system are interrelated, and it provides several examples of how estimates, or predictions, produced by the model have spotlighted erroneous data, supplied missing data, and anticipated data that become available only later. Most important, the model provides a general structure that is not necessarily restricted to heroin, but may be applicable to other illegal drug systems.

The Model and How It Works

4. The key to the design of the model was the notion that the behavior of the heroin system in the United States would be affected most importantly by how much heroin is available at any time (inventory) in comparison with the amount the addicts want (desired inventory). This ratio is referred to in the model as the Relative Abundance Measure. This indicates the surplus, adequacy, or shortage of the heroin supply at any time. This, in turn, affects directly such things as heroin price, purity, and the number of heroin users. These influences are depicted in figure 1.

Figure 1
Ratio of Heroin Supply Influences



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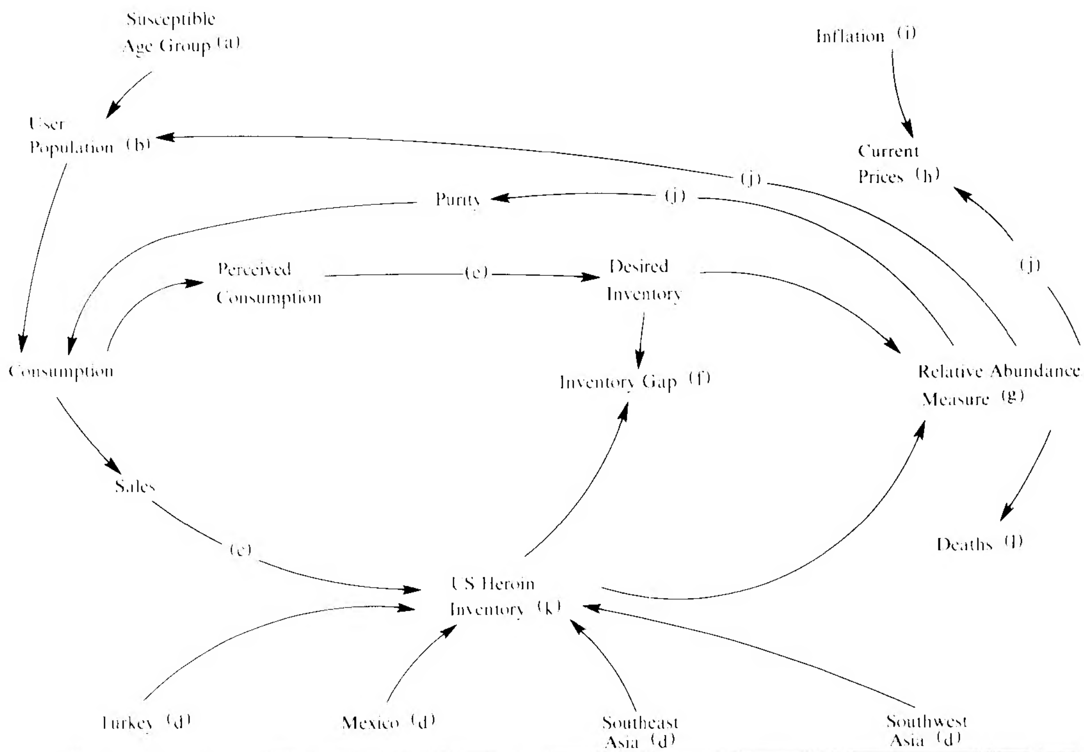
5. As is often the case, these relationships appear simplistic and obvious once described, but they are not so apparent beforehand. In addition, to get to the essence of what makes the system work, some of the clutter of conflicting data must be resolved. In this model only one factor was troublesome—the definition of a heroin user. There are heavily addicted users (who spend substantial amounts of time in jail); light, sporadic users; and moderate users who fall between these extremes. The heavy users are comparatively few, the occasional users comparatively many. For the purposes of this model, using National Institute of Drug Abuse (NIDA) data, we created an "average" user who consumes a package of heroin a day that contains 22.6 milligrams of pure heroin when the US inventory is at the desired level. As will be seen later, the purity of the heroin consumed and the number of users both increase when supply increases more than consumption and decrease when there is a shortage of heroin. Total consumption is thus affected by both the number of users at any time and the purity of the heroin in the package they buy.

6. In the heroin problem, as in most other social problems, the important factors in the system are

Figure 2
Complete Diagram of Interrelationships of Heroin Supply Influences



a. At the upper left-hand corner is the Susceptible Age Group. This group consists of the 14- to 34-year-olds in the population as derived from census data. The User Population is a fraction of this group that varies with the availability of heroin—the Relative Abundance Measure. If desired, the User Population could be shown as responding to Price, in which case Price would reflect supply/demand and User Population would change with Price. As will be explained later, Price is not directly affected as it is in normal marketing systems, and the Relative Abundance Measure was selected as the more appropriate factor to use.

b. The size of the User Population, and the Purity of what addicts buy determines Consumption. The various classes of users and the amounts they normally use per day are not treated separately, but they could be if desired.

c. Sales to support Consumption reduce the US Heroin Inventory.

d. The four sources of heroin imports since 1973 for the US heroin market are arrayed at the bottom of the figure in the order in which they first delivered supplies to the United States.

e. The Desired Inventory is taken as five times the weekly Perceived Consumption. This provides a slight buffer against small variations in overall supply, but holds down risks of loss. Perceived Consumption serves to represent the lag in the response of the operators in the system to the ups and downs in Consumption in the short term.

f. The Inventory Gap is merely the difference between the Desired Inventory and the actual inventory, the US Heroin Inventory.

g. The Relative Abundance Measure provides a single index for the actual/desired inventory status. This ratio affects both the heroin User Population and the Purity of the heroin it buys.

h. As distinct from purchases of other things, such as bread, beans, or bacon, the addict does not buy heroin directly at so many dollars per milligram but buys instead a package in which the amount of pure heroin is small and variable. Thus, price per milligram is indirectly derived.

i. In the model, Price (per milligram pure) is related to the Relative Abundance Measure and Inflation. The values for inflation are taken from the Commodity Price Inflation Index.

j. The relationships between the Relative Abundance Measure and Purity, Price, and the Heroin User Population are of particular interest. Purity and the Heroin User Population are parts of loops—that is, the Relative Abundance Measure affects Consumption, which affects the US Inventory, which affects the Relative Abundance Measure, which affects Purity, and on and on. A similar situation exists with the Heroin User Population. Thus, changes in Purity and Heroin User Population affect Consumption and the US Inventory, and these are influenced by the Relative Abundance Measure.

k. Over the 10-year span, the ratio of the US Inventory to the Desired Inventory ranges from a low of 0.8 (undersupply) to 1.8 (oversupply). Purity bottoms out at about 3.5 percent when it is in short supply, rises rapidly until the Inventory overage amounts to about 50 percent, and then begins to taper off slightly. The variation in Population is much less dramatic, falling a bit when heroin is in short supply and increasing significantly only when the excess is greater than 20 percent. Prices come down as heroin becomes more abundant, but seem to bottom out at $0.90 per milligram of pure heroin.

l. As described in the main body of this Memorandum, the effect of the Relative Abundance Measure on deaths is more complex than the effect of the ratio on Purity, Price, and User Population. The system exhibits two modes of behavior, one when the ratio is rising and the other when it is falling.

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numerous and highly interrelated, and this makes analysis based on pure reasoning (that is, without the use of analytical aids) difficult, tiring, uncertain, and almost impossible to retrace. One function of the model is to make the relationships clear and explicit, and then let a computer perform the tedious processing. We do this by creating a "decision rule" about, for example, how much on the average the purity in a package of heroin will rise as the available quantity of heroin increases; we express this rule as a mathematical reference in the model, and then let the computer calculate purities as the imports of heroin rise and fall. The multiple effects of the factors influencing the behavior of this model are shown in figure 2.

7. Considering these influences, and given the heroin imports described below, the model forecasts what the user population, purity, prices, and heroin-related deaths will be. These predictions are generally referred to as the model's behavior, and the way the model behaves is determined by the influences, or structure, described above. Whether the model can be used confidently is largely dependent on how closely the predictions of the model match their real-life counterparts: for example, at any given moment, does the model's predictions for purity match independently measured national averages for purity? The independently measured values for purity, price, and heroin-related deaths are not direct inputs for the model. They are used only for comparison with the model-generated estimates to assist in evaluating how well the model behavior matches real-life behavior. The particular question here is whether the model will provide good predictions using only the fluctuating heroin imports over the last 10 years as the input to the model.

Model Inputs

8. The sources and amounts of heroin imports used in the model correspond, with a single exception discussed later, to the sources and amounts commonly accepted by the various agencies concerned with drug abuse. These inputs are shown in tabular form in table 1 and graphically for the same 10-year period in figure 3.

9. The data for total heroin imports are plotted again in figure 4, which shows how these imports relate to the Relative Abundance Measure. Using expert opinion, we built into our model the assumption that heroin traffickers attempt to hold five weeks' supply (at the current consumption rate) as a buffer against surges in demand and delays in supply. This provides a degree of inertia in the system and causes changes in the Relative Abundance Measure to lag behind the changes in Imports. The relatively high amount of heroin on hand when the model begins in 1973 results from a sustained growth in heroin imports from Mexico before 1973.

Model Validity

10. There are no absolutely valid models because such models would have to replicate any real world "system" faithfully and exhaustively in even the most trivial detail. All models, including all mental models, are simplifications. However, as described earlier, if the key factors influencing the system are identified and correctly interrelated, the behavior, or predictions, of the model will parallel the behavior of the real system closely enough to validate, or provide confidence in, the model. In addition, confidence in the accuracy of the model is enhanced when its behavior, using inputs from the "real" world, does not violate common sense. The following discussion deals with one dimension of the model—its ability to predict the size of the addict population—for which there are no usable matching independent data by which to show the model's validity but where the value of the model is demonstrated by its ability to spot a possible error in the data supplied to the model. Three areas in which data *are* available for comparison with numbers the model generates—purity, price, and heroin-related deaths—are then discussed. By matching the figures that the model generates on these three subjects with the independently measured numbers, we can determine how accurately the behavior of the model parallels the behavior of the real system.

Heroin User Population

11. Figure 5 shows the decision rule which states how the Relative Abundance Measure affects the size of the user population. The effect of the Relative Abundance Measure on the user population is quite constant when the inventory and the desired inventory are nearly balanced, but lowers the population slightly when shortages occur and increases the population slowly with increases in supply—that is, an 80-percent

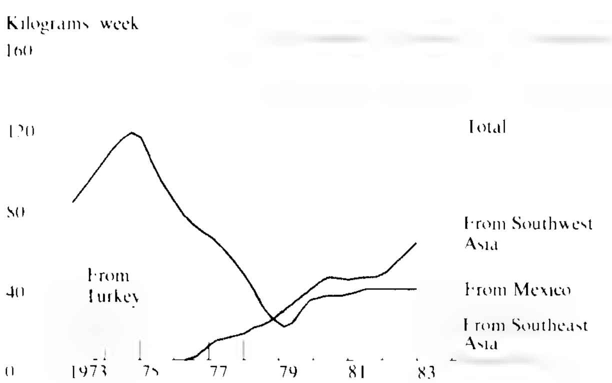
Table 1

Heroin Imports Into the United States, 1973-83
(in pure metric tons)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983 [a]
Turkey	1.0	0.5									
Mexico	3.7	5.0	5.6	4.0	3.1	1.9	1.0	1.7	1.8	1.8	
Southeast Asia			1.0	2.0	2.0	1.7	1.2	0.4	0.4	0.7	
Southwest Asia					0.4	0.8	1 4	2.1	2.2	2 7	
Total	4.7	5.5	6.6	6.0	5.5	4.4	3.6	4.2	4.4	5 2	5.4

[a] The 1983 estimate procedure is described in paragraph 17.

Figure 3
Heroin Imports Into the United States



Estimated

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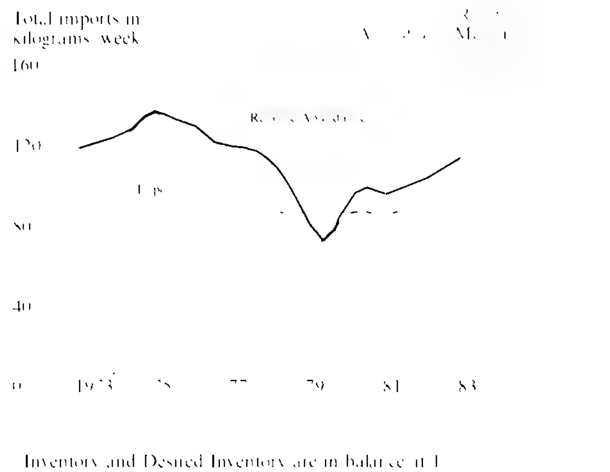
Figure 4
Comparison of US Heroin Imports and Relative Abundance Measure



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oversupply produces only a 10-percent rise in the population. Our model shows only how changes in the Relative Abundance Measure affect the *percentage* of change in the user population. The actual number of addicts added or subtracted depends on the size of the 14- to 34-year-old age group. As the size of this group increases, logically the user population will also increase for any given Relative Abundance Measure.

12. The addict population numbers the model produces do not violate common sense and are consistent with other estimates available from various surveys and analyses. However, good data on the actual size of the addict population in the United States do not exist. Consequently, the validity of the model cannot be checked by comparing the numbers it produces with independent user population measurements. The model-estimated user population is shown in figure 6. As a baseline from which to observe fluctuations in the size of the addict population that are independent of the normal growth that occurs as the 14- to 34-year-old age group increases, we derived an estimate from NIDA figures that the addict population equals 0.65 percent of the 14- to 34-year-old population when supply and consumption are in balance. The natural demographic increase in that percentage is shown in the figure as a "reference group" against which the size of the addict population predicted by the model rises and falls in relationship to how much heroin is available. The size of the population swelled with the growing availability of heroin through 1975, and then remained fairly constant through 1978 even though the amount of heroin available dropped, because the

Figure 5
Effect of Relative Abundance on Heroin User Population

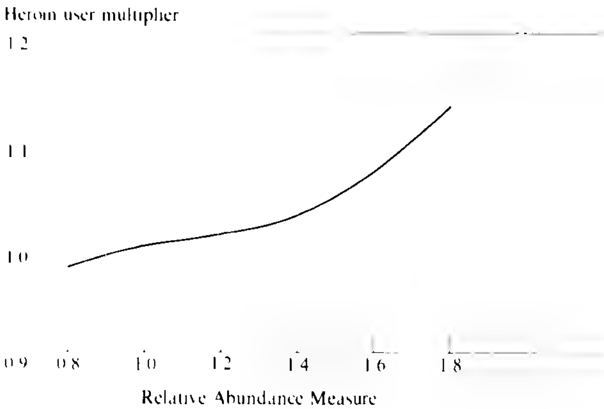

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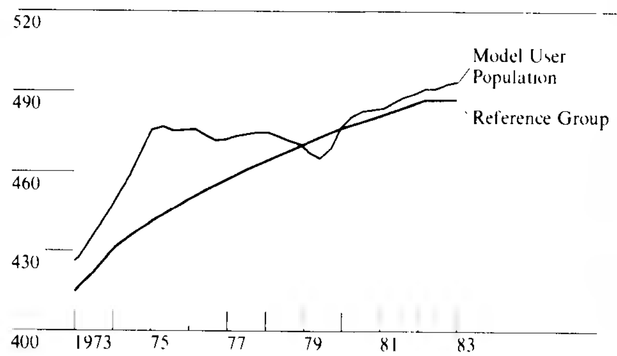
Figure 6
Effect of Relative Abundance Measure on Heroin User Population



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growing age group population offset the decline in the percentage of the age group addicted to heroin.

13. Even though we cannot independently verify that the model's user population projections are accurate, we were able to use them to reveal a logical inconsistency between one of the import figures used as an input to the model and the size of the user population that the model indicates would be required to consume that amount of heroin. Originally, the estimate for heroin imports for 1975 supplied to the model included 6.5 tons from Mexico instead of the 5.6 tons shown in table 1. This was inconsistent with the size of the heroin user population predicted by the model for that year. In particular, the *rate* of increase in the size of the population would have had to have *jumped* considerably to produce a user population large enough to consume so much heroin. This would run contrary to the common sense notion that, since there is probably an upper limit on the fraction of the total population that might become heroin users (as there is for cigarette smokers), the *rate* of increase should tend to *subside* as heroin becomes more abundant. In addition, that much surplus heroin would have had effects on purity and price that were not born out by the data available for that year. Because of these inconsistencies, we double-checked the import figures and discovered that 5.6 tons provides a better "fit" and is consistent with other independently available information. This is one illustration of the way in which dynamic model development can highlight logical inconsistencies that may not be apparent until otherwise plausible data are viewed against a comprehensive and consistent framework.

Heroin Purity

14. The way the Relative Abundance Measure affects purity in the model is shown in figure 7. When heroin is in relatively short supply, the amount of pure heroin in the package the user buys is also low. When heroin supplies are abundant, the amount of pure heroin increases. Unlike the user population, purity changes quite dramatically with changes in the Relative Abundance Measure. As with the user population, however, the amounts of change are not constant but depend on the adequacy of heroin supply that exists at any particular time.

15. Samples of heroin have been analyzed by the Drug Enforcement Administration (DEA) for purity over the years, and the comparison of these data with the model-generated purity values is shown in figure 8. In view of the simplicity of the model and the sampling and statistical problems involved in determining purity, the correspondence between the purity measured in the heroin samples and the purity estimated by the model over the 10-year period is surprisingly good. Only annual average purity values

Figure 7
Effect of Relative Abundance on Heroin Purity

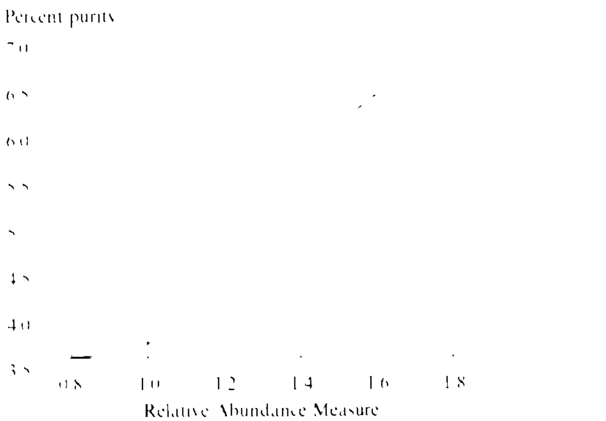

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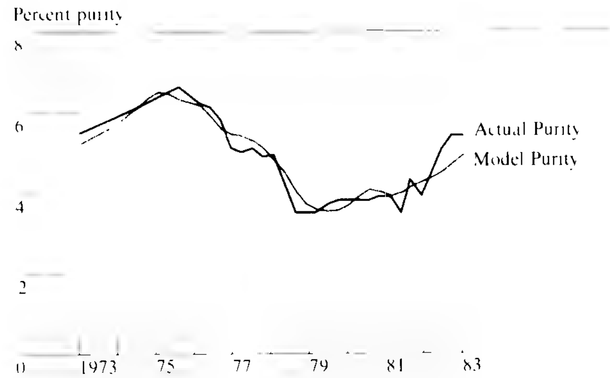
Figure 8
Actual Heroin Purity Versus Model Purity



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are used for 1973, 1974, and 1975, after which quarterly values are available. Since purity figures in the model are derived in part from known imports, and because the correspondence between sample and model purity data is so close, we can reverse the procedure and use known purity figures to estimate what imports were at a given time. We have used this procedure three times to produce "missing" import figures. In the first instance, we used sample purity data which do exist from earlier years to estimate what the residual imports from Turkey must have been in the 1973-74 period following the halt in Turkish production in 1972. We have no figures from other sources on Turkish imports for these years. With data only for Mexican imports, the model-generated purity values fall well below the 5.1 percent and 5.8 percent found in sample data. The amount of imports from Turkey that we have inserted in table 1 and figure 3 are those required to cause model purity to be consistent with the observed system values. These imports are intuitively reasonable and "fill in the blanks."

16. The second case in which we used purity figures to derive imports was in attempting to estimate overall imports for 1982. Our original information was that imports for 1982 were about the same as in 1981. This, however, resulted in model purity values for 1982 that were quite a bit lower than the measured purity values. Here again, comparison of model and sampled purity suggested that the imports were understated. Subsequently, estimates of the imports from Southeast and Southwest Asia were revised upward by the DEA. While this brings the model and real-world data into good correspondence, the total imports still appear to be slightly underestimated.

17. In addition to using purity figures to double-check available import statistics, we have used them to produce an estimate of how much heroin was imported into the United States in 1983. This estimate is not yet available from other sources. Using the DEA measured values for purity for 1983, the model indicates that some 5.4 metric tons of heroin would have had to be imported into the United States in that year to generate model purity values that correspond to the measured numbers. To check the validity of this import figure, we also generated model prices for 1983 to see if they would correspond to available measured street prices. The correspondence was good: street prices for the first three quarters of 1983 (the fourth-quarter prices are not yet available) vary from $2.28 to $2.43 per milligram, and the model prices range from $2.22 to $2.45.

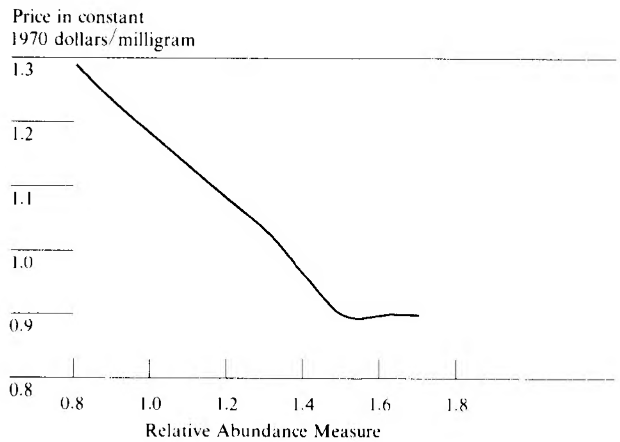
Heroin Prices

18. Price moves opposite to purity with changes in the Relative Abundance Measure. Also, as shown in

figure 9, the prices fall in an almost straight line as the Relative Abundance Measure rises, but then level off rather suddenly (in constant 1970 dollars) as a price floor is reached below which it does not make economic sense (in part because of the personal risk involved) for a trafficker to continue to deal in heroin.

19. This lower limit on prices influenced prices strongly during the buildup of imports, and accompanying surpluses, into 1975. With a growing surplus of heroin supply over consumption, a continuing drop in price might have been expected, but instead the price floor was reached and, in fact, nominal prices rose slightly because of the effects of inflation. Notice, as shown in figure 10, that the model price estimates are higher than the observed prices in 1982—another indicator that the estimated imports may be low.

Figure 9
Effect of Relative Abundance on Heroin Price



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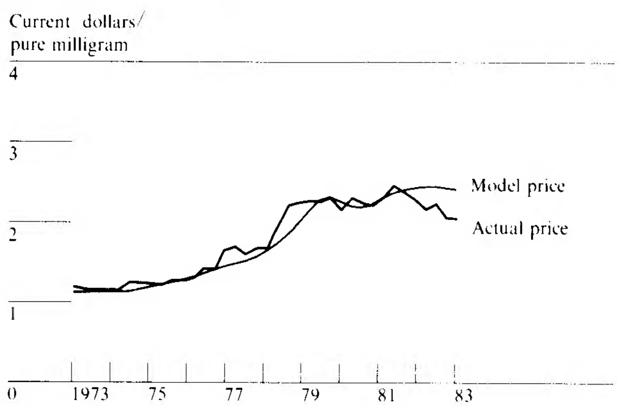
Heroin-Related Deaths

20. Figure 11 shows how the relative abundance or shortage of heroin affects the number of heroin-related deaths. This is more complex than the purity and price relationships because two distinct modes operate—one when the amount of heroin is increasing and the other when the supply is falling. This is required because, when the supply of heroin is falling, the death rate does not retreat along the same path that it followed when supplies were increasing. Use of only the rising relationship results in major departures between model-produced death estimates and the measured values. These two modes are believed to reflect the effect of purity changes as the Relative Abundance Measure rises and falls. When supply is increasing, and purity is also increasing, the addict is subject to unexpectedly high doses, which may be fatal. On the other hand, when supplies and purity are falling, the likelihood of overdosing, either accidentally or deliberately, is reduced.

Figure 10
Comparison of Model Price and Actual Price of Heroin



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21. Figure 12 compares the heroin deaths reported from 1973 through 1981 with the model's predictions. It is important to appreciate that the definition of what constitutes heroin-caused or heroin-related deaths is neither precise nor uniform in the United States. Contributing factors, such as alcohol, are often present, so the need for subjective judgments is understandable and unavoidable.

22. The reason 1982 sample data are incomplete illustrates, in part, the problems encountered in obtaining "hard data." The number of heroin-related deaths in New York City is still being negotiated, because such deaths are recognized only when confirmed by a toxicological examination. If a victim is found in surroundings where the cause of death seems apparent—for example, heroin scattered about and a syringe in hand—a toxicological exam may not be made and the death accordingly not tallied as heroin

Figure 11
Effect of Relative Abundance of Heroin on Deaths

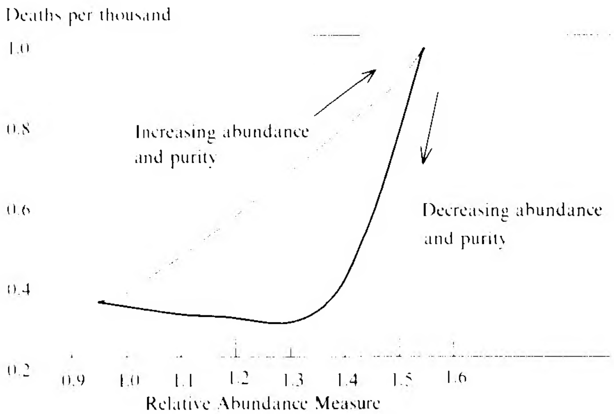

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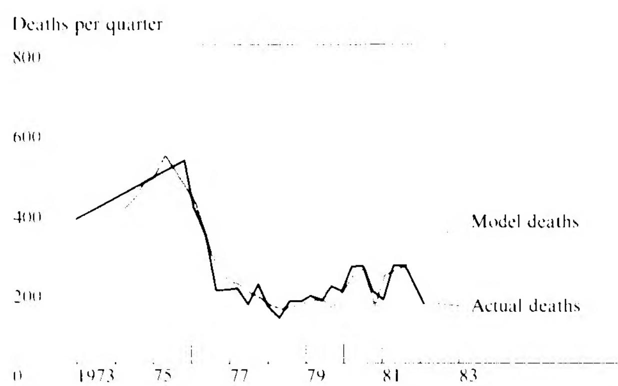
Figure 12
Comparison of Model Deaths and Actual Deaths From Heroin



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related. The model indicates, however, that deaths probably rose in 1982; we await confirming data.

Implications and Possible Future Applications

23. This modeling effort is still in a developmental phase. We need additional time and research to determine how robust it is and whether it can be applied with equal facility to other aspects of the heroin market in the United States, whether it can be extended to non-US markets, and whether it can be adapted to deal with illegal drugs other than heroin. In terms of pursuing possible future applications of this model to the US heroin market, of the various relationships demonstrated among elements of the heroin situation by the model, the one that stands out as potentially most exploitable involves purity. The notion that purity measurements of seized or purchased samples tend to rise and fall as heroin supplies grow and shrink has long been known. However, the relative precision with which the model predicted changes in heroin purity over a 10-year period indicates a relationship between purity and such other factors as imports and consumption that is sufficiently strong to suggest the use of purity figures alone as a powerful, timely indicator of the state of heroin abundance in the United States at any given moment. In particular, it may be possible to use purity figures to estimate whether, and how much, imports of heroin and the size of the US heroin addict population are expanding, holding steady, or declining. The advantage of using purity as an indicator for these other factors is that purity measurements are usually available on a fairly "real time" basis, while import statistics are often several months late and sometimes have to be deduced from fragmentary evidence, and there are no consistent figures on addict population size. 25X1

24. One problem with using purity measurements other than for what they intuitively suggest is that purity often varies sharply among daily samples obtained in different regions of the United States and among individual samples within a region. The large variations in purity at the local level have tended to mask the relationship with the other dimensions of heroin supply and consumption that are revealed when averages are used. The model uses national averages, thus smoothing out the momentary peaks and valleys and providing data that can be compared with other aggregate figures, such as total imports and changes in the national user population. 25X1

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26. Another type of regional model that might be developed is one representing the supply-and-demand situation in producing countries. If purity and price data were available (for example, in Bangkok and Karachi), it might be possible to create a model that would indicate how much heroin was available from the country soon after each opium poppy harvest was completed. Knowing these quantities in turn might provide a much more accurate and timely understanding than we have at present of how much heroin is available in that regional market for export.

27. A further interesting application of the model would be to attempt to use it to understand supply-and-demand relationships for other illegal drugs. To the extent that such drugs as cocaine, marijuana, and certain synthetics follow the same basic dynamics as heroin supply and demand, they could be modeled in the same fashion. Much more ambitious, but theoretically equally feasible, would be to design and develop a comprehensive, integrated national drug model, using the system dynamics "loom" to weave the various individual drug systems together. A key advantage that might be afforded by such a model would be a better understanding of the addicts who use multiple drugs—the polyusers—and the trade-offs that might occur in concentrating intelligence and law enforcement resources against particular drugs in the system.